(12) Unexamined Laid-open Patent Publication (A)

(19) Japanese Patent Office

(11) Patent Publication No. 7-322121

(43) Publication Date: December 8, 1995

(51) Int. Cl. FI

H04N 5/228 Z

5/335 V

5/907 B

Request for Examination: Not yet requested

Number of claims: 4

(Total Pages 10)

(21) Application No. 6-106640

(22) Date of filing: May 20, 1994

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(54) [Title of Invention] HIGH PICTURE QUALITY IMAGE INPUT DEVICE

(57) [ABSTRACTS]

[PURPOSE] To obtain the images or high picture quality with use of an image pickup element having a small number of pixels and

without increasing the size of an image input device.

[CONSTITUTION] When the light 201 received from a subject 111 is photographed by an image pickup device 113, the optical axis of the light 201 is changed by an optical axis changing device 112. At the same time, the subject 111 is photographed by plural times by the device 113 together with the position control carried out by a shift detecting device 114 which detects the shifts of images by the video signal received from the device 113, an optical axis controller 115 which controls the device 112, and a driver 116. Thus, plural images of different optical axes can be obtained from the same subject so that plural images of different pixels which are actually photographed can be obtained by a single image pickup device. Then a single image is produced from those images. Therefore the images of high picture quality can be obtained by an image pickup device that has a simple constitution as a whole and also has a small number of pixels.

[CLAIMS]

[claim 1]

A high-definition image input device, comprising:

an optical axis changing device for changing an optical axis of light received from a subject;

an image pickup device for photographing the light from the subject whose optical axis is changed by said optical axis changing device;

a memory which stores an image signal outputted from said

image pickup device;

a shift detecting device which detects a shift of an image using a video signal outputted from said image pickup device;

an optical axis controller which controls said optical axis changing device based on the information on the amount of pixel shift outputted from said shift detecting device;

a driver which moves said optical axis changing device to a prescribed position based on a control signal given from said optical axis controller; and

a control unit which controls an operation which writes an image signal outputted from said image pickup device into said memory and an operation which reads out an image signal currently stored in said memory.

[Claim 2]

A high-definition image input device, comprising:

an optical axis changing device for changing an optical axis of light received from a subject;

an image pickup device for photographing the light from the subject whose optical axis is changed by said optical axis changing device;

a memory which stores an image signal outputted from said image pickup device;

a shift detecting device which detects a shift of an image using a video signal outputted from said image pickup device;

an optical axis controller which controls said optical axis

changing device based on the information on an amount of pixel shift outputted from said shift detecting device;

a driver which moves said optical axis changing device to a predetermined position based on a control signal given from said optical axis controller;

a position detector which detects a position of said optical axis controller and sends out a signal showing a position of said optical axis changing device to said optical axis controller; and

a control unit which controls an operation which writes an image signal outputted from said image pickup device into said memory and an operation which reads out an image signal currently stored in said memory.

[Claim 3]

The high-definition image input device as recited in claim 1 or 2, further comprising an image composition apparatus which creates one image from a plurality of image signals read out from said memory, wherein said image composition device is disposed at the latter part of said memory.

[Claim 4]

The high-definition image input device as recited in claim 1 or 2, further comprising a computer input terminal for deriving a plurality of image signals read out from said memory to a computer, and wherein said plurality of image signals are inputted into a computer and subjected to an image composition within said computer.

[Detail description of the invention]

[0001]

[Field of the invention]

The present invention relates to a high-definition image input device, and is preferably used as a high-definition image input device which can obtain a high-definition image by photographing a plurality of images while shifting an optical axis of light from a subject by an optical axis changing device and then composing the aforementioned plurality of photographed images into one image.

[0002]

[Prior Art]

In recent years, a definition of image pickup element such as a CCD has been improved. Furthermore, it has become in practical use and has become popular that the color of the light from a subject is separated by a dichroic mirror and is photographed by a plurality of camera tubes or image pickup elements.

[0003]

Apart from the aforementioned system, there is another system by which a color image is photographed by photographing a color image while rotating a color-filter disc in front of a monochrome camera tubes and/or a monochrome image pickup element and also rotating another color-filter disc in front of an observer synchronizing with the aforementioned color disc.

[0004]

Furthermore, in the field of an endoscope, the lighting light is set in color plane sequentially and a color image photographing is performed with a single image pickup element. Then, the image signal obtained by the aforementioned image photographing is stored in the image memory, and each color image can be displayed and observed simultaneously by reading out from the aforementioned image memory.

[0005]

[Object to be solved by the invention]

In the aforementioned prior art, since CCDs having high pixels are used, the high-definition image input unit becomes expensive. Furthermore, in the case of the apparatus using a dichroic mirror and a plurality of camera tubes or an image pickup element, there is a problem that the apparatus itself is large. Furthermore, in another prior arts, since additional new apparatus is required, there is a problem in cost, size and the like.

[0006]

In view of the aforementioned problems, it is an object of the present invention to obtain a high-definition image by using an image pickup element with a smaller number of pixels and without enlarging an apparatus.

[0007]

According to a high-definition image input device, the device includes:

an optical axis changing device for changing an optical axis

of light received from a subject;

an image pickup device for photographing the light from the subject whose optical axis is changed by the optical axis changing device;

a memory which stores an image signal outputted from the image pickup device;

a shift detecting device which detects a shift of an image using a video signal outputted from the image pickup device;

an optical axis controller which controls the optical axis changing device based on the information on the amount of pixel shift outputted from the shift detecting device;

a driver which moves the optical axis changing device to a prescribed position based on a control signal given from the optical axis controller; and

a control unit which controls an operation which writes an image signal outputted from the image pickup device into the memory and an operation which reads out an image signal currently stored in the memory.

[0008]

According to another feature of the present invention, a high-definition image input device, includes:

an optical axis changing device for changing an optical axis of light received from a subject;

an image pickup device for photographing the light from the subject whose optical axis is changed by the optical axis changing

device;

a memory which stores an image signal outputted from the image pickup device;

a shift detecting device which detects a shift of an image using a video signal outputted from the image pickup device;

an optical axis controller which controls the optical axis changing device based on the information on an amount of pixel shift outputted from the shift detecting device;

a driver which moves the optical axis changing device to a predetermined position based on a control signal given from the optical axis controller;

a position detector which detects a position of the optical axis controller and sends out a signal showing a position of the optical axis changing device to the optical axis controller; and

a control unit which controls an operation which writes an image signal outputted from the image pickup device into the memory and an operation which reads out an image signal currently stored in the memory.

[0009]

According to still another feature of the present invention, the high-definition image input device further includes an image composition apparatus which creates one image from a plurality of image signals read out from the memory, wherein the image composition device is disposed at the latter part of the memory.

[0010]

According to still yet another feature of the present invention, the high-definition image input device further includes a computer input terminal for deriving a plurality of image signals read out from the memory to a computer, and wherein the plurality of image signals are inputted into a computer and subjected to an image composition within the computer.

[0011]

[Function]

Since the present invention includes the aforementioned technical means, at the time of picking up the light from the subject, the aforementioned subject is photographed a plurality of times by one image pickup device while changing the optical axis of the aforementioned light. Therefore, although the subject is the same, since the optical axis differ, a plurality of images whose pixels are different from those of actually photographing pixels can be obtained by using a single image pickup device. By creating one image from these plural images, a high-definition image can be obtained by using an image pickup device with smaller number of pixels and simple structure.

[0012]

[Embodiment]

Hereinafter, one example of the high-definition image input device according to the present invention will be explained with reference to the drawings. Fig. 1 shows one example of the present invention, and is a block diagram showing the schematic structure

of the high-definition image input device.

[0013]

As shown in Fig. 1, in the high-definition image input device of this example, the optical axis of the light from the subject 111 is changed by the optical axis changing device 112, and the light 201 passed through the aforementioned optical axis changing device 112 is photographed by the image pickup device 113.

[0014]

Then, the video signal 202 photographed and obtained by the aforementioned image pickup device 113 is supplied to the motion detector 114 to detect the shift of the image. Furthermore, the information 203 on the shift amount of the pixel outputted from the aforementioned motion detector 114 is supplied to the optical axis controller 115. This optical axis controller 115 controls the optical axis changing device 112.

[0015]

That is, the aforementioned optical axis controller 115 outputs the VAP control signal 204 for changing the optical axis to a driver 116, and this driver 116 moves the aforementioned optical axis changing device 112 to a predetermined position. Then, a position detector 120 detects the position of the aforementioned optical axis changing device 112, and the signal 214 showing the position is sent out to the optical axis controller 115. Thus, a position control with high precision can be performed. In addition, the optical-axis-controller control signal 208 is given to the

aforementioned optical axis controller 115 from the CPU 119, and a control based on this control signal 208 is also performed.

[0016]

The reference numeral 117 denotes a memory for storing the image signal 205 outputted from the aforementioned image pickup device 113. The reading-and-writing operation of the aforementioned memory 117 is controlled by the frame memory control signal 209 given from the CPU 119. The reference numeral 118 denotes an image composition device which composes a plurality of image signals 206 read out from the memory 117 into one video signal 210 and then outputs it. Furthermore, the reference numeral 119 denotes a CPU for controlling the aforementioned optical axis controller 115, the memory 117 and the image composition device 118.

[0017]

In addition to the aforementioned overall schematic structure of the high-definition image input device of according to the present invention, the concrete structure of each portion thereof will be explained with reference to Figs. 2 to 11.

[0018]

Fig. 2 is a structural view showing a high-definition image input device according to a second example of the present invention. The high-definition image input device according to the second example shown in Fig. 2 is provided with a VAP (Variable Angle Prism) 121 as an optical axis changing device for changing the optical

axis of the light from the subject 111.

[0019]

Furthermore, the high-definition image input device includes a lens system 122 through which the light 201 from the VAP 121 passes, an image pickup device 113 which photographs the subject 111, a motion detector 114 which detects the shift amount of the pixel from the video signal 202 from the image pickup device 113, and an optical axis controller 115 which controls the VAP 121 based on the information 203 on the shift amount of the pixel from the motion detector 114.

[0020]

The high-definition image input device is further provided with a driver 116 for moving the VAP 121 to a predetermined position based on the VAP signal 204 given from the optical axis controller 115 and a memory selecting switch 123 which selects one of a plurality of frame memories 125-128 each for storing the image signal 205 from the image pickup device 113.

[0021]

The high-definition image input device is further provided with a read-out selecting switch 124 for selectively reading out the data from a first frame memory ① 125 to a fourth frame memory ④ 128, each of which stores the image signal 205 from the image pickup device 113, and an image composition device 118 which composes a plurality of images read out from the first frame memory ① 125 to the fourth frame memory ④ 128 into one image and outputs

the image as a video signal 210.

[0022]

The high-definition image input device is further provided with a video output terminal 130 for outputting the video signal 210 outputted from the image composition device 118 to an external apparatus and a CPU 119 which controls the optical axis controller 115, the memory selecting switch 123, the read-out selecting switch 124 and the image composition device 118. The aforementioned CPU 119 controls each of the aforementioned portions based on the output 207 outputted from the motion detector 114.

[0023]

Now, the structure of the aforementioned VAP 121 will be explained briefly. Fig. 7 is a schematic structural view showing the VAP 121. As shown in Fig. 7, the VAP 121 is constituted such that the optical axis of the light from the subject 111 can be changed in the direction of a yaw (right-and-left direction) and the direction of a pitch (up-and-down direction) using two lenses 301 and 302.

[0024]

The lens 301 is driven in the direction of a yaw by the coil 303 constituting a voice-coil motor. The coil 303 is driven by a coil drive circuit 307 which is controlled by a control circuit 309.

[0025]

Furthermore, the position of the lens 301 in the direction

of a yaw is detected by the position sensor 305, and is fed back to the control circuit 309. Similarly, the position of the lens 302 in the direction of a pitch is detected by the position sensor 305 and is fed back to the control circuit 309, and the operation thereof is controlled by the coil 304 and the coil drive unit 308, and the position is detected by the position sensor 306.

[0026]

The aforementioned VAP 121 is usually disposed in front of the lens system 310 in order to shift the optical axis minutely in the direction of a yaw (right-and-left) and the direction of a pitch (up-and-down).

[0027]

Next, the operation of the second embodiment will be explained. First, the subject 111 is photographed by the image pickup device 113, and the image is stored in the first memory 125 to the fourth memory 128. In this case, the memory selecting switch 123 selects the first frame memory ①125 based on the memory selecting-switch control signal 211 received from the CPU 119. Thus, the image signal 205 from the image pickup device 113 is stored in the first frame memory ① 125 selected by the memory selecting switch 123.

[0028]

Next, the VAP 121 is minutely moved in the direction of a yaw (right) to perform one pixel shift in the direction of a yaw (right). The shift amount of the pixel is detected by the motion detector 114. That is, the motion detector 114 checks the video

signal 202 from the image pickup device 113, performs a comparison between the last image and the current image, detects the shift amount of the pixel between the image of last time and this time, and outputs the information 203 on the shift amount of the pixel to the optical axis controller 115.

[0029]

The optical axis controller 115 controls the VAP 121 such that the current video image is shifted by one pixel in the direction of a yaw (right) as compared with the last image based on the information 203 on the shift amount of the pixel outputted from the motion detector 114. Then, when the video image is shifted by one pixel in the direction of a yaw (right), the memory selecting switch 123 selects the second frame memory ② 126. Thereby, the image signal 205 from the image pickup device 113 is stored in the second frame memory ② 126 selected by the memory selecting switch 123.

[0030]

Next, the VAP 121 is minutely moved in the direction of a pitch (downward), and one-pixel shifting is performed in the direction of a pitch (downward). At this time, based on the information 203 on the shift amount of the pixel from the motion detector 114, as compared with the last image, the optical axis controller 115 controls the operation of the VAP 121 such that the current vide image is shifted by one pixel in the direction of a pitch (downward).

[0031]

Then, when the video signal is shifted by one pixel in the direction of a pitch (downward), the memory selecting switches 123 selects the third frame memory ③ 127. Thereby, the image signal 205 from the image pickup device 113 is stored in the third frame memory ③ 127 selected by the memory selecting switch 123.

[0032]

Next, the VAP 121 is minutely moved in the direction of a yaw (left) which is opposite to the previous direction, and one image shifting is performed in the direction of a yaw (left) which is opposite to the previous direction. The optical axis controller 115 controls the operation of the VAP 121 based on the information on the shift amount of the pixel from the motion detector 114 such that one pixel shift in the direction of a yaw (left) which is opposite to the previous direction is performed as compared with the last image.

[0033]

Then, when one pixel shift is performed in the direction of a yaw (left) which is opposite to the previous direction, the memory selecting switch 123 selects the fourth frame memory ④ 128. Thereby, the image signal 205 from the image pickup device 113 is stored in the fourth frame memory ④ 128 selected by the memory selecting switch 123.

[0034]

As mentioned above, the same subject 111 is photographed while

shifting it in the direction of a yaw and the direction of a pitch by one pixel, respectively. The photographed image is stored in four frame memories, or the first frame memory ① 125 to the fourth frame memory ④ 128, in order, respectively.

[0035]

Next, the data currently stored in the first frame memory ①125 to the fourth frame memory ④ 128 is read out and outputted by the selecting switch 124 based on the read-out selecting-switch control signal 212 given by the CPU 119. Then, the pixel signal 205 selected by the selecting switch 124 is given to the image composition device 118. The image composition device 118 composes a plurality of images into one image according to the image-composition-device control signal 215 given by the CPU 119, and outputs the image as a video signal 210 via the video output terminal 130.

[0036]

Figs. 8 and 9 show the relation between the image pickup area and the subject image. As illustrated, the optical axis of the light from the subject 111 is focused on the image pickup area of the image pickup device 113 by the optical axis changing device 112. Thus, the subject image P1 (hatched portion) is obtained. Fig. 8(a), Fig. 9(a) and Fig. 9(b) show the relation between the image pickup area of the CCD of the complementary color mosaic filter and the subject image focused on the image pickup area when shifted by one pixel relative to the original subject image P1 rightward,

right-downward and downward, respectively.

[0037]

That is, Fig. 8 (a) shows the positional relation between the image pickup area and the original subject image P1. Fig. 8 (b) shows the relation between the image pickup area and the subject image P2 shifted by one pixel rightward relative to the original subject image P1.

[0038]

Fig. 9 (a) shows the relation between the image pickup area and the subject image P3 shifted by one pixel right-downward relative to the original subject image P1. Fig. 9 (b) shows the relation between the image pickup area and the subject image P4 shifted by one pixel downward relative to the original subject image P1.

[0039]

Thus, four images can be obtained to the same subject image by shifting by one pixel at a time rightward, right-downward and then downward relative to the original subject image P1 and picking up each subject. Although these four images are obtained by photographing the same subject, the pixel which is actually photographing is different. For example, the upper right pixel of the subject image focused on the image pickup area is Y (yellow) in Fig. 8 (a), C (cyan) in Fig. 8(b), and M (magenta) in Fig. 9(a) and G (green) in Fig. 9(b).

[0040]

Thus, by photographing the same subject while shifting it by one pixel at a time, a total of four images can be obtained as compared with the conventional image pickup method. Thus, a high-definition image can be obtained by composing these four images into one image.

[0041]

Fig. 3 is a schematic structural view showing a high-definition image input device according to a third embodiment of the high-definition image input device of the present invention. In Fig. 3, the explanations corresponding to the same portion as in the aforementioned embodiment will be omitted, and only the newly added function will be explained. The newly added in this third embodiment is the VAP position detector 131.

[0042]

That is, in the aforementioned second embodiment, the VAP 121 is controlled by the optical axis controller 115 and the driver 116 based on the information 203 on the shift amount of the pixel from the motion detector 114.

[0043]

To the contrary, in this third embodiment, the position of VAP 121 is detected in the VAP position detector 131, the VAP positional information 213 is drawn to the optical axis controller 115 and the data of the position of VAP 121 is fed back. As mentioned above, by providing the feedback loop of the position data, the accuracy of position control can be greatly improved.

[0044]

Fig. 4 is a schematic structural view showing a high-definition image input device according to a fourth embodiment of the present invention. In Fig. 4, explanations of the same portions as in the aforementioned two embodiments will be omitted, and only the newly added function will be explained. In this embodiment, the VAP 121 for shifting an optical axis employed in the aforementioned embodiments was replaced with parallel plates 133.

[0045]

That is, in this fourth embodiment, the parallel plates 133 are provided between the lens system 122 and the image pickup device 113. Based on the information 203 on the shift amounts of the pixel from the motion detector 114, the parallel plates 133 are controlled through a driver 116 by the optical axis changing device 115.

[0046]

Fig. 5 is a schematic structural view showing a high-definition image input device according to a fifth embodiment of the present invention. In Fig. 5, explanations of the same portions as in the aforementioned embodiments will be omitted, and only the newly added function will be explained.

[0047]

In this embodiment, the parallel plates position detector 132 is provided. That is, in the second embodiment mentioned above, the parallel plates 133 are controlled by the optical axis controller 115 based on the information 203 on the shift amount

of the pixel from the motion detector 114. However, in this fifth embodiment, The position of the parallel plates 133 is detected in the parallel plates position detector 132, and the data showing the parallel plates position 214 is fed back to the optical axis controller 115.

[0048]

Fig. 6 is a schematic structural view showing a high-definition image input device according to the sixth embodiment of the present invention. In Fig. 6, explanations of the same portions as in the aforementioned embodiments will be omitted, and only the newly added function will be explained. In this embodiment, a computer input terminal 134 is newly provided. In the aforementioned embodiments, the image is converted into the video signal 210 in the image composition device 118, and outputted to an external appliance from the video output terminal 130. To the contrary, in this sixth embodiment, the image signal from the image pickup device 113 is stored once in the frame memory 129. Then, the image signal is inputted into a computer (not shown) from the computer input terminal 134, an image composition is performed within the computer.

[0049]

In the aforementioned embodiments, the image shifting is performed by one pixel. However, the image shifting may be performed by half-pixel, and it may be performed to photograph between the pixels so as to enhance the definition of the image.

Figs. 10 and 11 are explanatory views showing the image pickup area and the subject image at the time of performing a half-image shifting using a complementary color mosaic filter.

[0050]

Fig. 10 (a) shows the positional relation between the image pickup area and the subject image Q before performing an image shifting. Fig. 10 (b) shows the image pickup area at the time of shifting the optical axis of the light from a subject rightward by a half-pixel and focusing the image on the image pickup area and the subject image Q. This figure shows that the subject is photographed in the image pickup area in the right-and-left direction between pixels.

[0051]

Fig. 11 (a) shows the image pickup area at the time of shifting the optical axis from the subject by a half-pixel right-downward and focused onto the image pickup area and a subject image Q. This figure shows that the image pickup area photographs the subject in the slant direction between pixels. Fig. 11 (b) shows the image pickup area at the time of shifting the optical axis from the subject by a half-pixel rightward and focused onto the image pickup area and a subject image Q. This figure shows that the image pickup area photographs the subject in the vertical direction between pixels.

[0052]

As mentioned above, an image of a high resolution and high definition can be obtained by composing a plurality of images

photographed the same subject while performing pixel shifting into one image. Furthermore, it becomes possible to further improve the quality of image by photographing a total of sixteen images of the same subject while combining one-pixel shifting and half-pixel shifting.

[0053]

The present invention is not limited to one-pixel shifting or a half-pixel shifting. The present invention allows to perform any desired pixel shifting, such as 1/4-pixel shifting or 1/8-pixel shifting, and also allows to combine these pixel shifting. Furthermore, the motor for driving the VAP 121 may not be limited to the voice-coil motor, but may be a stepping motor or another motor.

[0054]

[Effects of the Invention]

According to the present invention, as mentioned above, since a plurality of images are obtained by photographing a subject image a plurality of times while shifting the optical axis of the light focused on the image pickup device for photographing the subject, a high-definition image can be obtained only by composing these plural images into one image. Accordingly, a high-definition image can be obtained easily, without using an expensive image pickup element of high pixels or using a plurality of image pickup elements or camera tubes.

[0055]

Furthermore, according to another features of the present invention, since the position detector which detects the position of an optical axis changing device and sends out the signal showing the position to the optical axis controller is provided, the position control of the optical axis changing device can be performed with high precision.

[Brief description of the drawings]

[Fig. 1]

Fig. 1 is a schematic structural view showing a high-definition image input device according to a first embodiment of the present invention.

[Fig. 2]

Fig. 2 is a schematic structural view showing a high-definition image input device according to a second embodiment of the present invention.

[Fig. 3]

Fig. 3 is a schematic structural view showing a high-definition image input device according to a third embodiment of the present invention.

[Fig. 4]

Fig. 4 is a schematic structural view showing a high-definition image input device according to a fourth embodiment of the present invention.

[Fig. 5]

Fig. 5 is a schematic structural view showing a high-

definition image input device according to a fifth embodiment of the present invention.

[Fig. 6]

Fig. 6 is a schematic structural view showing a high-definition image input device according to a sixth embodiment of the present invention.

[Fig. 7]

Fig. 7 is a schematic structural view showing a VAP.

[Fig. 8]

Fig. 8 is an explanatory view concerning an image pickup area and a subject image.

[Fig. 9]

Fig. 9 is an explanatory view concerning an image pickup area and a subject image.

[Fig. 10]

Fig. 10 is an explanatory view concerning an image pickup area and a subject image.

[Fig. 11]

Fig. 11 is an explanatory view concerning an image pickup area and a subject image.

[Explanation of the reference numeral]

111 Subject

112 Optical axis changing device

113 Image pickup device

114 Motion detector

115 Optical axis controller

116 Driver

117 Memory

118 Image composition apparatus

119 CPU

120 Position detection apparatus

121 VAP

122 Lens system

123 Memory selecting switch

124 Read-out selecting switch

125 Memory ① (the first frame memory)

126 Memory ② (the second frame memory)

127 Memory ③ (the third frame memory)

128 Memory ④ (the fourth frame memory)

129 Frame memory

130 Video output terminal

131 VAP position detection apparatus

132 Parallel plates position detection apparatus

133 Parallel plates

134 Computer input terminal

201 Light

202 Video signal

203 Information on the amount of pixel shift

204 VAP control signal

205 Image signal

208 Optical-axis-controller control signal

209 Frame-memory control signal

210 Video signals

211 Memory selecting-switch control signal

212 Read-out selecting-switch control signal

213 VAP positional information

214 Parallel plate positional information

215 Image composition apparatus control signal

301 Yaw direction lens

302 Pitch direction lens

303 Yaw direction voice-coil motor

304 Pitch direction voice-coil motor

305 Position sensor

306 Position sensor

307 Coil drive circuit

308 Coil drive circuit

309 Control circuit

[Fig. 8]

PIXEL

ORIGINAL PHOTOGRAPHIC OBJECT IMAGE P1

PHOTOGRAPHIC OBJECT IMAGE SHIFTED RIGHTWARD BY ONE PIXEL P2

[FIG. 9]

ORIGINAL PHOTOGRAPHIC OBJECT IMAGE P1

PHOTOGRAPHIC OBJECT IMAGE SHIFTED RIGHTWARD BY ONE PIXEL P2

PHOTOGRAPHIC OBJECT IMAGE SHIFTED RIGHT DOWNWARD BY ONE PIXEL P3

PHOTOGRAPHIC OBJECT IMAGE SHIFTED DOWNWARD BY ONE PIXEL P4

[FIG. 10]

PIXEL

SUBJECT IMAGE Q

IMAGE PICKUP AREA AT THE TIME OF SHIFTING RIGHTWARD BY A HALF-PIXEL

IMAGE PICKUP AREA OF FIG. 9(a)

[FIG. 11]

PIXEL

SUBJECT IMAGE Q

IMAGE PICKUP AREA AT THE TIME OF SHIFTING RIGHTWARD BY A HALF-PIXEL

IMAGE PICKUP AREA OF FIG. 10(a)

IMAGE PICKUP AREA AT THE TIME OF SHIFTING RIGHT DOWNWARD BY A

HALF-PIXEL

IMAGE PICKUP AREA AT THE TIME OF SHIFTING DOWNWARD BY A HALF-PIXEL